NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Evaluating Thin Client Computers for Use by the Polish Army

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June 2006

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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 2006	MBA Professional Report

4. TITLE AND SUBTITLE: Evaluating Thin Client Computers for Use by the Polish Army	5. FUNDING NUMBERS
6. AUTHOR(S) Krzysztof K. Felisiak and Pawel S. Grunt	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited	A

13. ABSTRACT *(maximum 200 words)*

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14. SUBJECT TERMS Thin Client	15. NUMBER OF PAGES 83
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

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Approved for public release; distribution is unlimited

EVALUATING THIN CLIENT COMPUTERS FOR USE BY THE POLISH ARMY

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
June 2006

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LIST OF ABBREVIATIONS

CAD	Computer Aided Design
CAL	Client Access License
GUI	Graphical User Interface
ICA	Independent Computing Architecture
IT	Information Technology
LAN	Local Area Network
NC	Network Computer
OS	Operating System
RDP	Remote Desktop Protocol
ROI	Return on Investment
TCO	Total Cost of Ownership
TS	Terminal Server
WBT	Windows Based Terminal

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ACKNOWLEDGMENTS

We express our sincere thanks to our advisors, Dr. Douglas E. Brinkley and Dr. Raymond E. Franck, and the faculty of the Naval Postgraduate School for their insight, knowledge and direction. We would also like to thank our families for their understanding, patience and continuous support.

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I. INTRODUCTION

In the past decade, the costs of maintaining and modernizing information technology (IT) infrastructures in a defense environment have risen significantly. Defense-oriented institutions and organizations all over the world have been looking for a compromise between costs and modern, secure and effective IT systems. Recently, the long-forgotten thin clients have returned to the market, advertised as a panacea for this dilemma and a successful alternative to infrastructures based on traditional PCs.

In this project, the authors will examine the technical capabilities of thin client devices to determine if they can successfully replace traditional PCs within a Polish Army command environment. To accomplish this, a prototype thin client network will be built and the compatibility of the system using software applications used by the Polish Army will be tested. The authors will also analyze the costs of implementing and operating a thin client-based network compared to a traditional PC network. The project will also investigate the feasibility of exporting thin client technology to Poland and try to determine what, if any, trade restrictions are involved. The results of the project will be used to recommend whether thin client devices should be included in the Polish Army's future IT modernization efforts.

In the beginning of the project, the authors will introduce the background and historical information and theory associated with thin client technology. Then, the advantages and disadvantages of thin client technology will be presented. Afterwards, examples of companies and organizations that successfully implemented thin clients will be given.

For the purpose of testing software compatibility and performance, a model of a simple thin client network will be built. Using this model, the authors will test popular software used in the Polish Armed Forces to find out if this software is compatible with a thin client environment. Subsequently, compatible software will be used in testing

where the authors will compare their perceptions of the software performance in the thin client environment to the traditional PC network. Afterwards, the results of this test will be presented.

The project will also explore technology transfer restrictions, and the availability of thin client technology on the Polish market will be examined. The basics of software licensing will be explained and recommended software packets will be given. The cost comparison models will be built and presented. The costs associated with each model will be calculated and depicted. The preferable model will be chosen and explained.

Finally, the authors will summarize their findings and share their comments, perceptions, and opinions about thin client technology. The project will be finalized with the recommendation for the Polish Armed Forces to either implement or not implement thin client technology. The authors will also recommend the most efficient use of thin clients in the Polish Armed Forces and provide some future recommendations.

II. THIN CLIENT – THE THEORY

A. BACKGROUND

The rising cost of maintenance for networked PCs, along with growing software complexity and new security threats, has prompted information technology (IT) users and experts to examine thin client computing technology.

Server-based computing was established long before the term "thin client" appeared in IT terminology. The first input/output terminals consisted of a keyboard for input and a cathode ray tube (CRT) display for data output. Due to the high cost of early computer hardware, the processing power and memory had to be shared across users and all computing needed to be server based.[1] This was a logical solution since it was easier and less expensive to add more input/output devices rather than buy computers that are more expensive as demand for computing power increased. This solution was the beginning of what is commonly referred today as dumb terminals, "which, as the name suggests, are simply input/output devices with no processing power of their own".[2]

More complex thin client computing began in the late 1970s with the introduction of a system called X Windows, an interface that allowed users to access UNIX applications through a graphical user interface (GUI) on a reduced, smaller version of what is known today as a personal computer (PC). To transmit all of the operations between the X terminal and the UNIX server, a specific network protocol known as X11 was developed and implemented.[3]

The invention of microprocessors and the introduction of the first PCs equipped with sufficient storage and memory and capable of running applications revolutionized computing processes. Gradually, computer users shifted away from server-based

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[1]"What is Thin-client Computing?" (cited 15 February 2006); available from World Wide Web @http://www.thinclient.net/technology/history.htm#Background

[2]Tushar Barnum, Praveen Kurup, "Thin-client Computing," (cited 15 February 2006); available from World Wide Web @http://zdnetindia.nc-india.com/coverstories/stories/44694.html

[3]"Is thin In?" in University Business Magazine, (cited 15 February 2006); available from World Wide Web @http://www.universitybusiness.com/page.cfm?p=547

computing and focused more on bringing applications and processing power directly onto their desks. This form of computing has been dominant for years. However, around 1996 Oracle and Sun Microsystems brought the attention back to thin clients by announcing a "hardware reference for what they would term the Network Computer (NC)".[4] The NC, like the X terminal, was designed to provide access to centralized applications and databases on larger servers. The commonly used Citrix software followed this trend a couple of years later and enabled a system similar to X11 protocols called independent computing architecture (ICA), which is a standard for server-based computing today. Along with the maturing of the marketplace, more complete solutions have been developed in terms of hardware and software, Today, Tarantella, Citrix's Metaframe, and Sun's hardware/software solutions are the best, the most known, and the most often used systems in thin client computing.[5]

Thin client computing is a very fast growing sector of IT. The thin client market is expected to grow at a compound annual growth rate of 20.7% from 2005 to 2009, significantly outpacing the overall growth rate of the PC market.[6] In comparison to the networked PC model, thin client computing is generally a more cost-effective alternative. The new trend in IT – centralization of assets - makes thin client solutions even more attractive.

B. THIN CLIENTS BASICS

1. Thin Client Definition

From many definitions found in literature, the two given below reflect the essence of the issue the best.

A thin client is:

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[4]"Is thin In?" in University Business Magazine, (cited 15 February 2006); available from World Wide Web @http://www.universitybusiness.com/page.cfm?p=547

[5]Tushar Barnum, Praveen Kurup, "Thin-client Computing," (cited 15 February 2006); available from World Wide Web @http://zdnetindia.nc-india.com/coverstories/stories/44694.html

[6] "Wyse Technology Dominates Thin-client Market for Eighth Consecutive Year," (cited 19 February 2006); available from World Wide Web @http://uk.wyse.com/about/news/pr/2005/0712_IDC.asp

1) A user's computer that performs no application processing. It functions like an input/output terminal, processing only keyboard and mouse input as well as screen output, and all application processing is done in the server. This is a “thin processing” client and is accomplished using Windows Terminal Server, Citrix Presentation Server and X Window.

2) A user's computer that performs all the application processing, but stores nothing locally. It downloads the application from the server, runs it, and returns any updated data to the server. The next time the program is run, it is downloaded again. This is a “thin storage” client that is embodied in the network computer, which never became popular.[7]

Following the first part of the definition provided above it can be said that the thin clients are simple devices designed to run applications from a server instead of from the PC, equipped with no hard drive, CD-ROM, floppy drive, expansion slots, or any other moving part. This allows them to be smaller, thus saving office space, and facilitates a rapid deployment of a large number of the devices. The term "thin" comes from the little amount of processing executed on the client where in case of a “fat” client most of the processing is performed on the client.[8]

Most of the thin clients contain the following features: [9]

- Built-in RDP, ICA or other protocol for server-based computing.
- An Ethernet connection and optional support for wireless LANs.
- I/O for keyboard and mouse, optional I/O for printers, USB and other peripherals.
- A video processor for strong graphics and colors.
- Solid-state construction – no moving parts such as fans or disk drives.
- Centralized software management and deployment.

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[7]Thin-client definition, (cited 28 January 2006); available from World Wide Web @http://www.pcmag.com/encyclopedia_term/0,2542,t=thin+client&i=52832,00.asp

[8]“Thin-client Networking” in Becta Technical Papers, (cited 22 January 2006); available from World Wide Web @http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/thin_client.pdf

[9]“Thin-client Characteristics,” (cited 10 January 2006); available from World Wide Web @http://www.thinclientcentral.com/howtochoose.htm

- Firmware-based software and no disk drives.

To communicate with the host servers, thin clients use specialized protocols and software such as Citrix MetaFrame and Microsoft Windows Terminal Server.[10]

The following table compares the features of thin and fat clients.

Feature	Thin	Fat
Run any Windows Application	Yes	Yes
Access OS/400, Mainframe, Unix and Web servers	Yes	Yes
Hard Drive	No	Yes
Runs Windows 95/98/NT/Me/2000 at the desktop	No	Yes
Moving parts such as cooling fan	No	Yes
Processes data at the desktop	No	Yes
Files are transferred from the desktop to server and back	Never	Yes
User access to Windows Control Panel	No	Yes
Requires hardware upgrades as technology changes	No	Yes
Needs to be moved when the user moves	No	Yes
User needs to perform file maintenance	No	Yes
Data lost if desktop machine is stolen	No	Yes
Virus protection required at each desktop	No	Yes
Updates at each desktop	No	Yes
Games and movies possible	No	Yes
Work Station or Entertainment Station	Work	Both

Table 1. What is Thin Client and What is Not? [11]

2. Types of Thin Client Networks

The thin client typology is mostly based on the number and types of processes carried out on the client.

10 J. R. Delaney, "The Thin-Client Alternative," (cited 10 January 2006); available from World Wide Web @http://www.pcmag.com/article2/0,1759,1730980,00.asp

11 "The Fourth Wave In Information Technology And Why You Should be Riding It" in Affirmative Computer Products LLC, 2003.

a. Ultra Thin Clients

Ultra thin clients are devices where only a keyboard, mouse and monitor are available for the user. The only task of an ultra thin client is to process the monitor graphical output and the user's mouse and keyboard input. The server executes all other processes and applications.[12]

b. Windows Based Terminals (WBT)

A distinctive feature of WBT is that they allow some processes, such as multimedia applications, to be executed on the client itself rather than on the server. WBT are "designed to complement the Windows operating system and Windows products."[13]

c. Internet Terminals

The main characteristic of internet terminals is the embedded internet browser, which allows the internet to be browsed directly from the client and excludes the server from the process.

d. Low Spec PC Solution

Low spec PC solution is based on the fact that in the thin client network the client itself runs very little processes. Therefore, older and modestly configured PCs can be used as terminals.

e. Tubby Clients

Tubby clients are PCs that run most applications and processes by themselves and, thanks to the networking software, can also contact the server and share its applications or computing abilities. This allows legacy software to be used on the PCs, while at the same time the new generation software can be installed on the server and executed there. This is particularly practical for the users who do not want to lose the ability to use critical older software. [14]

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[12] "Thin-client Networking" in Becta Technical Papers, (cited 22 January 2006); available from World Wide Web @http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/thin_client.pdf

[13] Ibid

[14] Ibid.

f. Disabled PC Solutions

Disabled PC solutions are simply standard PCs with the floppy and CD drive disabled, and configured to perform thin client tasks in the network.

g. Blade PC Architecture

Blade PC architecture or a high-density server is an expensive and new emerging technology.

> A Blade PC architecture uses PCs as individual servers as well as maintaining their PC function. These Blade PCs are held in a central location. A *manager server* controls these individual Blade PCs and manages load balancing between them. The users monitor, keyboard, mouse and other peripherals connect to a connection device on the desktop which in turn connects to the PC Blade chassis via a standard network cable connection (CAT-5).[15]

C. ADVANTAGES AND DISADVANTAGES OF THIN CLIENT COMPUTING

For most decision makers the main reason for switching to thin client computing is lower total cost of ownership (TCO), which in simple terms means maximizing the company's return on investment (ROI) in technology while minimizing the costs involved in doing so.[16] However, there are many more advantages to thin client computing than a better ROI. Correctly implemented thin client networks can not only reduce TCO but can also increase security and the quality of support, maintenance and service offering. Listed below are the main advantages of switching to thin clients.

1. Advantages of Thin Client Computing

a. Lower Total Cost of Ownership

The TCO includes both hard and soft costs. Hard costs are all capital costs, which include the procurement of hardware and software –the costs that are easy to

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[15] "Thin-client Networking" in Becta Technical Papers, (cited 22 January 2006); available from World Wide Web @http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/thin_client.pdf

[16] Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.12.

trace.[17] Soft costs are the costs associated with the intangible items, which include the costs associated with lower productivity due to downtime or training.[18] Normally, soft costs fall into three categories: "hardware maintenance, application support and end-user support."[19]

It is estimated that large organizations can save more than 50 percent in hard costs in the first year of thin client network deployment.[20] However, the greatest savings come from the reduction in soft costs, namely from reduced maintenance needs, lower IT staffing requirements and minimized demand on IT expertise as far as individual user's needs are concerned.[21]

b. Enhanced Security

One of the most important advantages of thin client computing is enhanced security. In a conventional desktop PC environment it is very hard to control the circulation of data. Moving applications from users' desks to servers increases the chances of being successful in protecting valuable data against viruses.[22] Although it is impossible to completely eliminate the risk of virus infections, centralized virus scanning and software removal reduces that probability to the possible minimum.[23]

Thin client computing allows the network administrator to control applications centrally. Without the administrator's permission, the regular user has no ability to access or modify unauthorized applications which in consequence reduces the risk of data loss. All operations are executed on the central server.[24]

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[17] Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.12.

[18] "Thin-client Technology – Increasing control and reducing costs with thin-clients" in Technical Resource Group White Paper, (cited 10 January 2006); available from World Wide Web @http://www.picktrg.com/pubs/ThinClient_WP062804.pdf

[19] Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.14

[20] "Increasing control and reducing costs with thin-clients" in Thin-client Technology

[21] Ibid.

[22] Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.22.

[23] Ibid, p.23

[24] Ibid, p.23

Thin client devices, unlike PCs, when stolen, are useless and worthless unless connected to a specific system, which makes them less attractive to thieves.[25] This can have a big impact on insurance fees.[26]

c. More Convenient Management of the System

The implementation of thin client technology results in the central management of IT resources and what follows is the "faster and more frequent deployment of new applications and software."[27] The centralization of activities leads to the reduction of time needed to perform support and maintenance operations. All application installations and upgrades are performed on servers. Server-based networking eliminates the need to install the applications on each individual device what "for the IT department brings almost immeasurable benefits in security, uniformity and data privacy."[28] The speed of software deployment increases dramatically, as instead of weeks or days it all happens in minutes or hours.[29]

> Furthermore, centralized management can solve some of the most troublesome problems facing IT, including data privacy and security, staffing shortage and the investment in technology purchases. It is estimated that 70 percent of a network administrator spend their time on end user issues. By using thin client technology IT personnel can devote more time to more challenging strategic work.[30]

d. Reusing Existing Technology

The new, more demanding software or operating system requirements are the main reasons for most required hardware upgrades. By switching to server-based computing, it is possible to eliminate these requirements and extend the life of the

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25 Newburn Consulting, "Thin-client Benefits," (cited 15 January 2006); available from World Wide Web @http://www.thinclient.net/technology/Thin_Client_Benefits_Paper.pdf

26 Ibid.

27 "Increasing control and reducing costs with thin-clients" in Thin-client Technology

28 Ibid.

29 Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.20.

30 "Increasing control and reducing costs with thin-clients" in Thin-client Technology

organization's desktop PCs. The ability to use conventional computers as clients introduces a cost reduction more importantly it eliminates the need of configuring each station individually.[31]

e. Licensing

Licensing is the main element of today's IT expenditure. Thanks to centralized application installation, licensing becomes easier to manage.[32] With thin client computing supplying the organization's workstations with the required software, application licenses become much simpler to manage compared to traditional PCs. If somebody needs to access a particular program the license availability is checked centrally and access is granted from the server.[33]

f. Energy Savings

Studies have shown that thin clients use considerably less power than traditional PCs. In comparison to conventional desktop devices, thin clients perform very little processing. According to different sources, power consumption of a thin client is approximately 14 to 20 percent of a PC.[34]

2. Disadvantages of Thin Client Computing

It needs to be understood that thin client technology will not satisfy all users. As with any new implementation, decision makers should take into consideration the specific requirements of the work environment and the goals they want to achieve by switching to the new technology.

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[31] Todd W. Mathers, "Windows NT/2000 Thin-client Solutions – Implementing Terminal Services and Citrix MetaFrame," (Macmillan Technical Publishing; 2000), p.20.

[32] Newburn Consulting, "Thin-client Benefits," (cited 15 January 2006); available from World Wide Web @http://www.thinclient.net/technology/Thin_Client_Benefits_Paper.pdf

[33] Ibid.

[34] Ibid.

a. User Acceptance

One of the greatest problems before, during and after thin client implementation is managing user acceptance.[35] The lack of CD and floppy drives, streaming video, and sound, as well as the impossibility of installing software may increase productivity but is also likely to reduce employee satisfaction from work. Some employees are so strongly tied to their favorite legacy software that they can not imagine their work without it. These are the problems with which top management personnel have to be prepared to deal with.

b. Demanding Environments

All data processing in thin client computing is done at the server. For graphic and data intensive applications such as terrain modeling via computer-aided design (CAD), where frequent screen redrawing is required, the data flow in the network increases to the unacceptable level.[36] In this case, fat clients are the better choice based on storage, memory, and access capability.

The benefits and disadvantages of thin client computing listed above are just the most popular examples. The reality shows that the implementation of this technology brings much more surprising results, which all depends on the environment in which it is used.

D. WHERE THE THIN CLIENTS CAN BE USED – EXAMPLES OF IMPLEMENTATION

Thin clients have traditionally been used in task-oriented applications – call centers for example. Current emphasis on cost reduction and centralization of IT assets is now causing thin clients to be used as a desktop PC replacement for almost all applications. Furthermore, thin clients, which were mainly used in transportation, retail, healthcare and education industries, are being adapted as a cost effective alternative to desktop PC solutions by new sectors such as financial services and government, as well

35 Newburn Consulting, "Thin-client Benefits," (cited 15 January 2006); available from World Wide Web @http://www.thinclient.net/technology/Thin_Client_Benefits_Paper.pdf

36 Ibid.

as military and manufacturing.[37] Any organization interested in a cost-effective, stable and secure desktop PC alternative can implement thin clients.[38]

Thin clients work well for numerous types of industries and employees. Some examples are described below:

Banking – Susquehanna Bancshares, Inc. - headquarters in Lititz, Pennsylvania. The company has 170 locations and 2,400 employees in Pennsylvania, Maryland, New Jersey, and West Virginia. Susquehanna has more than $7.5 billion in assets, owns eight community banks, two leasing companies, a credit life reinsurance company, a trust and investment company, an asset management company, and a property and casualty insurance brokerage.[39] Susquehanna adopted thin client technology in order to upgrade an aging decentralized IT infrastructure and ensure that the information and data needed to conduct business are easily accessible. The adopted system provides better access to more data, more control and monitoring capability of the IT infrastructure, and improves the company's overall IT security.[40]

Energy – Scottish and Southern Energy (SSE) produces over 10 percent of UK's energy and delivers gas and electricity to 5.5 million customers in the UK. SSE is also the country's largest producer of renewable energy. SSE introduced thin client technology due to its rapid expansion, as they needed a common user interface and computing environment. The thin client technology implemented at SSE's call-centre reduced complexity and improved manageability of its IT infrastructure.[41]

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37 "Thin-clients: helping Corporations Do More with Less" in Ziff Davis Media Custom Publishing 2004, (cited 04 January 2006); available from World Wide Web @http://www.wyse.com/resources/whitepapers/ZD.asp

38 "Demystifying the Thin-client Operating System: Which Thin-client Is Right for Your Business?," (cited 02 February 2006); available from World Wide Web @http://www.wyse.com/resources/whitepapers/ZDdemystify.asp

39 Susquehanna Bancshares, Inc., "Where the Center Holds, Wyse Case Study," (cited 02 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/WYSE/PDF/Banking_susquehanna.pdf

40 Ibid.

41 "HP Integrated Lights-Out technology keeps lights on in United Kingdom," (cited 22 January 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/HP/PDF/ScottishEnergy.pdf

Government – Rock County, WI, has a population of 154,000 residents that live within a 720 square-mile radius. The county officials wanted to reduce the cost of operations and consolidate IT resources while preserving legacy equipment to meet budget demands. As a result, they implemented thin client technology to support Rock County's IT team that served 29 departments. This solution enables them to use technology more efficiently and cost-effectively.[42]

Canadian Forces College is "the cornerstone in the development of the Canadian Forces' senior officer cadre."[43] The College faced problems with out-of date equipment when CPUs could not handle the school's simulation and exercise software. In addition the costs of maintenance, operation and upgrade were rapidly increasing. The College solved these problems by implementing thin client technology. At the same time, the thin client network reduced downtime, improved security, and increased network access for users.[44]

Rechenzentrum der Finanzverwalting NRW is a German company whose finance administration supports the German Treasury Ministry with IT service provided to tax offices. This support includes "tax calculations, compensation, reimbursements and mailings."[45] The company faced the task of refreshing the text-based terminals. The task involved replacing over 20,000 PCs and terminals. The thin client solution was chosen and more than 14,000 thin clients were deployed, leaving the PCs in use until they broke down. This resulted in better security and data protection, improved support and customer service, and allowed easy access to legacy applications.[46]

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42 "Ready to Rock," [case study] (cited 05 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/HP/PDF/uploads_casestudy_10.Rock%20CountyWI.pdf

43 "About the Canadian Forces College," (cited 15 February 2006); available from World Wide Web @http://www.cfc.forces.gc.ca/aboutcfc_e.html

44 "Customer Success Story Canadian Forces College," (cited 10 February 200); available from World Wide Web @http://ca.sun.com/en/aboutsun/success-stories/docs/cfc.pdf

45 "Thin-clients: helping Corporations Do More with Less," in Ziff Davis Media Custom Publishing 2004, [executive brief] (cited 04 January 2006); available from World Wide Web @http://www.wyse.com/resources/whitepapers/ZD.asp

46 Ibid.

Healthcare – Dreyer Medical Clinic in Aurora, Illinois is a multi-specialty practice that employs 125 physicians in twelve service locations across the Fox Valley. In 2001, Dreyer started changing the paper medical record system to a digital database with easy access from every location and every exam room or office. Therefore, the Clinic deployed low-cost thin clients at nursing stations with basic terminals as well as in exam rooms for on-demand access to medical records. This provided a reliable and secure client device to display Windows and Web applications. Ideal for healthcare, the thin client terminals have proven to be as efficient as and easier to maintain than PCs. The IT staff can perform all administration and maintenance from one place, because all servers are centralized at company headquarters. This allowed the implementation of the Health Insurance Portability and Accountability Act's (HIPAA) security protocols, improved patient care, and lowered costs operational costs.[47]

Distribution – Sernam is a division of the SNCF French National Railway, employs 10,000 people, and specializes in small package delivery. The company's IT network, which was composed of a complex mixture of aging PCs and servers, became a problem as systems started to perform badly. The modernization of the company's infrastructure was based on thin client technology. During the modernization process Sernam consolidated data centers, standardized software and gradually replaced PCs with thin client terminals, which significantly improved customer service and business flexibility as costs were reduced by one million Euros on an annual basis.[48]

FedEx is another example of a successful implementation of thin clients. The company deployed over 4,000 thin client terminals and continues to deploy more. Thanks to thin clients, FedEx reduced total cost of ownership (TCO) of its IT infrastructure by lowering hardware, support, and maintenance costs. The new infrastructure allows users

47 "An Ounce of Prevention Improves Patient Care and the Bottom Line," (cited 11 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/WYSE/PDF/Healthcare_dreyer.pdf

48 "Thin-clients: helping Corporations Do More with Less," in Ziff Davis Media Custom Publishing 2004, [executive brief] (cited 04 January 2006); available from World Wide Web @http://www.wyse.com/resources/whitepapers/ZD.asp

to "access Microsoft Office software and Windows based applications for customer service, ground operations and dispatch, as well as airport-based weather and maintenance operations."[49]

Education – The Chapel Hill-Carrboro City Public Schools system educates more than 10,000 K-12 students and consists of two high schools, four middle schools and eight elementary schools. The IT team of The Chapel Hill-Carrboro City Public Schools wanted to standardize applications and desktop configurations, centralize support and maintenance and finally, reduce the labor needed to support IT infrastructure. The thin clients helped to achieve that, and additionally created a new IT environment where students as well as teachers have access to assignments and school resources from both the classrooms and home. The thin client solution increased the reliability of the IT infrastructure and resulted in cost savings through reduced power consumption and lower support and maintenance.[50] Northern Humboldt Union High School District in Humboldt, California, is a similar example.[51]

Another education sector example is Birmingham Central Library in the UK, which installed a thin client network for public use. This solution provides basic control over the public using the library's network. The public is able to use standard software for word processing, spreadsheets, finance, drawing, and can access the internet. The system does not allow using disk drives and downloading software, which prevents the probable installation of computer viruses.[52]

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49 "Federal Express Memphis, Tennessee" in Winterm Success Story, (cited 15 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/WYSE/PDF/Distribution_fedex.pdf

50 "Chapel Hill-Carrboro City Public Schools, HP Success Story," (cited 15 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/HP/PDF/uploads_casestudy_3753_ChapelHill.pdf

51 "Northern Humboldt Union High School District, Humboldt, California" in Winterm Success Story, (cited 15 February 2006); available from World Wide Web @http://www.thinclientcentral.com/INDUSTRY_STORIES/WYSE/PDF/Education_northhumboldt.pdf

52 "Thin-client Networking" in Becta Technical Papers, (cited 22 January 2006); available from World Wide Web @http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/thin_client.pdf

> Other notable school examples include Hobbs Mill Wood Primary School which was the first UK school to implement its thin client solution using Microsoft Windows Server 2003, Millbourne Lodge Junior School which installed a new school network with new equipment as well as incorporating its old PCs into the thin client network and Bicester Community College, a large 11-18 school which also allows students access to the college network over the internet, so enabling home working.[53]

Aforementioned examples show that thin clients can be successfully implemented. Moreover, they show that thin clients are not only cheaper replacements of PCs, but they are comparable in capabilities and in areas such as security they are superior.

53 "Thin-client Networking" in Becta Technical Papers, (cited 22 January 2006); available from World Wide Web @http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/thin_client.pdf

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III. HARDWARE AND SOFTWARE TESTS

One of the main goals of the project was to examine the technical capabilities of thin client devices to determine if they could successfully replace traditional PCs within the Polish Armed Forces command environment. To accomplish this, the authors have built a prototype thin client network and tested the compatibility of the system using software applications used by the Polish Army. In addition, for the purposes of the project, the authors tested the performance of compatible software.

A. COMPATIBILITY TESTS

1. Model

In order to test the compatibility of the selected software and applications used in the Polish Armed Forces, a network that consisted of one server and three thin clients was built. The primary assumption was that if the software would run properly in such a network (authors would be able to run it on all stations simultaneously with the preservation of all features), the claim could be made that it was compatible with the thin client environment.

To make the tests more real and authoritative, the authors decided to use thin clients from different manufacturers. In the opinion of the authors, this will also decrease the chance of making a mistake and increase the probability of correctly determining whether the tested software is compatible or not with that kind of environment.

Figure 1 illustrates the graphical interpretation of the described model.

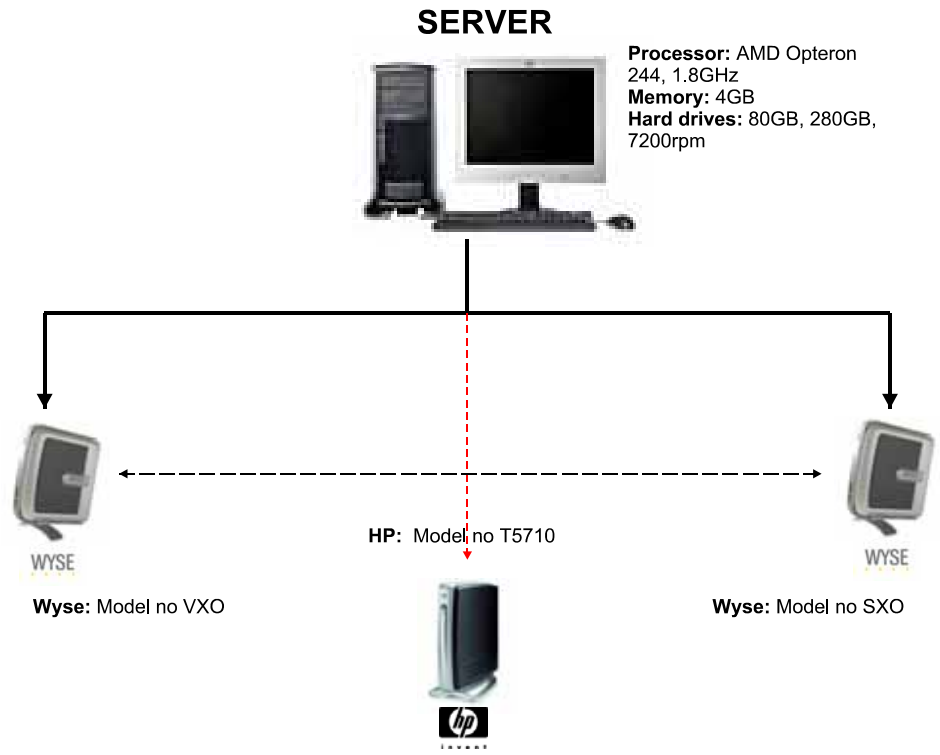

Figure 1. Thin Client network Model Used to Test the Compatibility of Selected Software (source: HP, Wyse)

2. Tests and the Results

In the results of conducted tests, the authors were able to determine which software and applications are compatible with thin client-based networks and which are incompatible.

The tests showed that none of the applications specific to the Polish Armed Forces was compatible with thin client devices. Tested applications designed to work in a disk operating system (DOS) environment were not recognized by and completely incompatible with the thin client environment. Applications such as Płatnik (Windows), Sfinks, Videotel, and e-PFRON did respond to the thin client computing environment. After the installation on the server they were accessible from the clients by different users. Unfortunately, all users had to have "administrator" status and only one user at the time, after logging in as the administrator, was able to run these applications. The bottom line is that none of the applications specific to the Polish Armed Forces was fully compatible with the thin client environment. The authors believe that it was caused by the

age of the software and the environment they were designed to run in. However, the authors questioned why relatively new applications like Płatnik were incompatible. In order to answer this question, the authors contacted Prokom Software SA., otherwise known as the author and owner of Płatnik software. The company representative answered that there was no need or market demand to develop a compatible version of software. The authors believe that this is also a reason why other applications were incompatible.

Table 2 lists the tested software and summarizes the results of the tests.

	Software	Environment	Compatibility	Remarks
1	Prosta – C	DOS	N	
2	Prosta – K	DOS	N	
3	Termin	DOS	N	
4	Podatek	DOS	N	
5	Trans	DOS	N	
6	Luz	DOS	N	
7	Mag-mat	DOS	N	
8	Ewpb	DOS	N	
9	Srtr	DOS	N	
10	Krab	DOS	N	
11	R 1 Krab	DOS	N	
12	Płatnik	DOS	N	
13	Spog Krab	DOS	N	
14	Kasjer	DOS	N	
15	Og	DOS	N	
16	S. Pozabud	DOS	N	
17	Sfinks_01	Windows	N	
18	Sfinks_02	Windows	N	
19	Sfinks_06	Windows	N	
20	Videotel	Windows	N	
21	Kav 5.0.372	Windows	N	
22	e-PFRON	Windows	N	
23	Płatnik	Windows	N	
24	Microsoft Word	Windows	Y	
25	Microsoft Excel	Windows	Y	
26	Microsoft PowerPoint	Windows	Y	

27	Microsoft Access	Windows	Y
28	Microsoft Visio	Windows	Y
29	Microsoft Frontpage	Windows	Y
30	Microsoft Project	Windows	Y
31	Microsoft Publisher	Windows	Y
32	Internet Explorer	Windows	Y
33	Adobe Acrobat	Windows	Y
34	WinZip	Windows	Y
35	Quick Time	Windows	Y
36	Real Player	Windows	Y
37	Windows Media Player	Windows	Y

Table 2. List of Software and Tests Results

B. PERFORMANCE EVALUATION

The second element in the practical part of the project was to evaluate the performance of the software running in a thin client-based network.

1. Model

To test and evaluate the performance of the compatible software, the authors built a network that consisted of one server and ten PCs working as thin clients. The reason for using PCs instead of regular thin client devices was the insufficient amount in possession of the latter. Nevertheless, the authors believe that the results of the tests can be considered as reliable. Figure 2 is the graphical interpretation of the model used to evaluate the performance of the software.

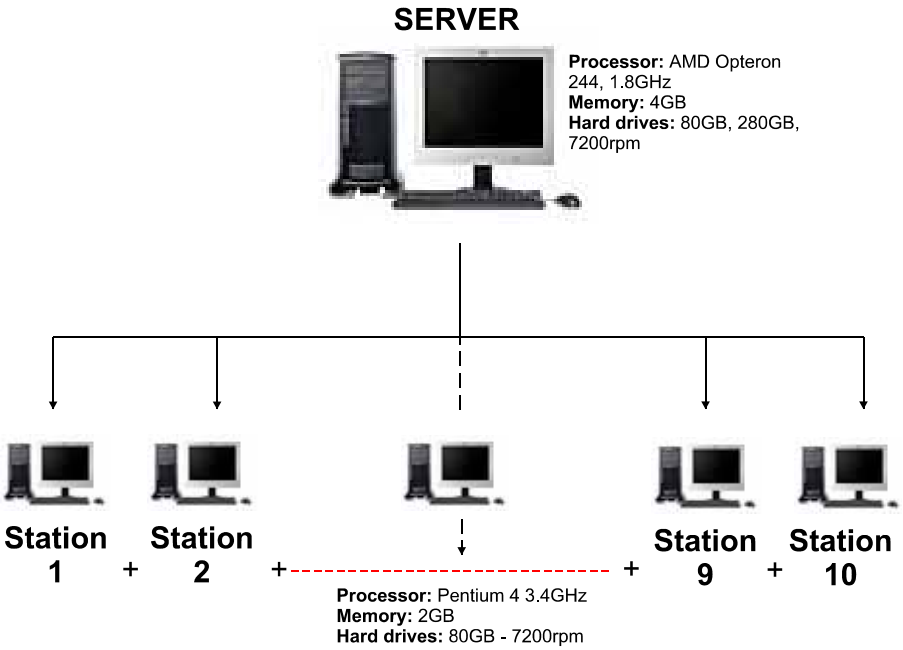

Figure 2. Graphical Model of the Network Used to Test the Performance of Selected Software (source: pictures HP)

2. Tests and the Results

The authors tested the compatible applications by running them on the built model and evaluated the performance of those applications by comparing their perceptions of the software performance in the PC environment to the thin client environment used in the model. To evaluate performance of the applications, the authors constructed an evaluation sheet where their subjective perceptions were recorded. The following figures represent the results of the evaluation conducted by the authors.

Figure 3 presents the evaluation of the thin client log-in procedure that the authors found to be equally complicated as standalone PCs, in the network where the user log-in procedure is required.

How complicated was the log-in procedure compared with a normal PC?
☐ Much more complicated
☐ More complicated
☒ Equal
☐ Easier
☐ Much easier

Figure 3. Evaluation of the Log-In Procedure

Figure 4 presents the performance evaluation of the tested applications. Except for media playing software, applications do not perform worse than in the PC environment. The performance of the tested environment was considered by the authors as not having a significant or noticeable difference between the two environments, i.e., thin clients and PCs. The "worse" and "definitely worse" marks for media performance are mainly caused by the video performance. The video files do not have steady flow and are of significantly worse quality compared to the standard PCs. Although the music files quality does not present the same inferiority as the video does.

	Definitely better	Better	Equal	Worse	Definitely Worse
Adobe Acrobat	☐	☐	☒	☐	☐
Microsoft Word	☐	☐	☒	☐	☐
Microsoft Excel	☐	☐	☒	☐	☐
Microsoft PowerPoint	☐	☐	☒	☐	☐
Microsoft Access	☐	☐	☒	☐	☐
Microsoft Visio	☐	☐	☒	☐	☐
Microsoft Frontpage	☐	☐	☒	☐	☐
Microsoft Project	☐	☐	☒	☐	☐
Microsoft Publisher	☐	☐	☒	☐	☐
WinZip	☐	☐	☒	☐	☐
Internet Explorer	☐	☐	☒	☐	☐
Quick Time	☐	☐	☐	☒	☐
Real Player	☐	☐	☐	☐	☒
Windows Media Player	☐	☐	☐	☐	☒

Figure 4. Performance Evaluation of the Selected Software

During the application evaluation the authors monitored the server's CPU usage. The observed CPU load was between 10 and 40 percent that in consequence guaranteed a fluent operation of the software on each emulated thin client station. The results showed that the usage of the server's processor hardly ever reached the maximum.

The CPU usage readings were taken in the following situations:

1. Users are not logged-in.
2. Users are logged-in, but no applications were running.
3. Users are logged-in and all of them run Internet Explorer.
4. Users are logged-in and each of them runs a different application.

Figures 5, 6, 7 and 8 represent the CPU usage for each of the above listed scenarios. Hardly any difference between the server's processor load in given phases can be observed. However, the authors believe that with each thin client station added to the network, the CPU usage would increase. In addition, at some point or with a certain amount of devices connected to the same server, the performance of the software would be much worse compared to traditional PCs, or the software would not run at all.

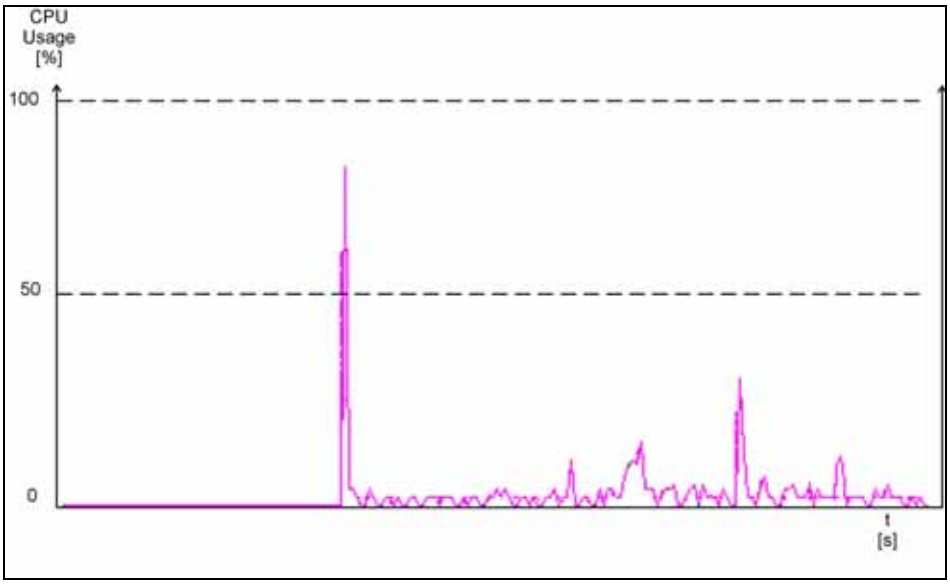

Figure 5. CPU Usage – Users not Logged-in

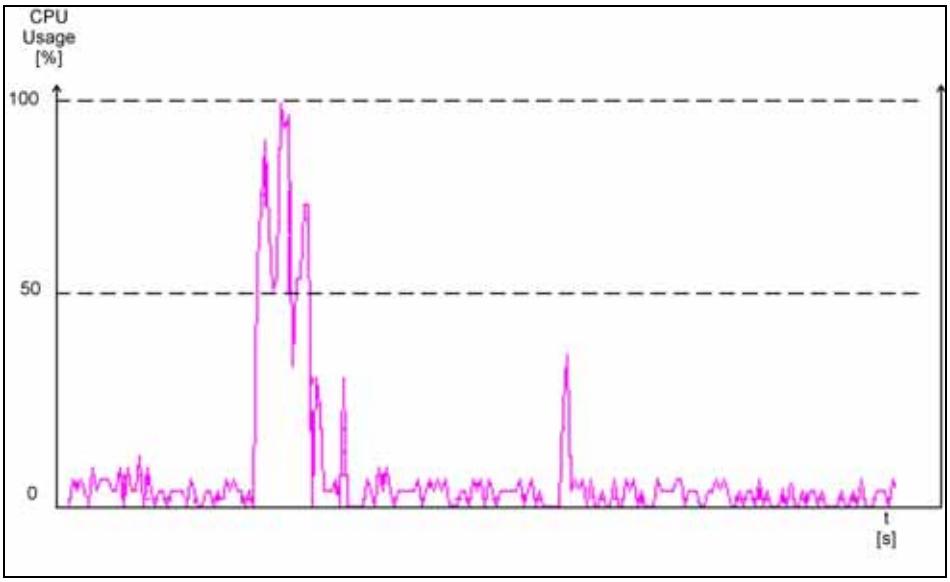

Figure 6. CPU Usage – Users logged-in, no Programs Running

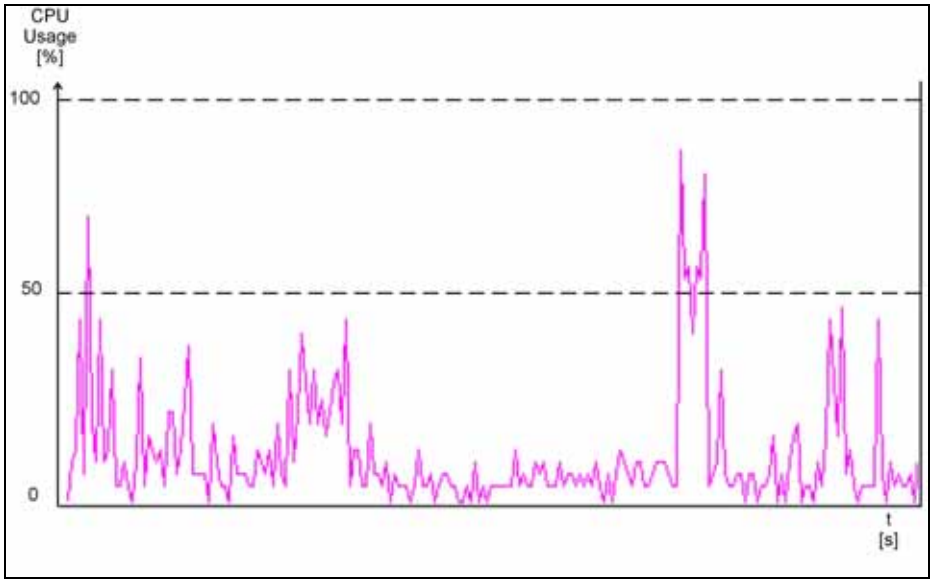

Figure 7. CPU Usage – Users Logged-in, Internet Explorer Running

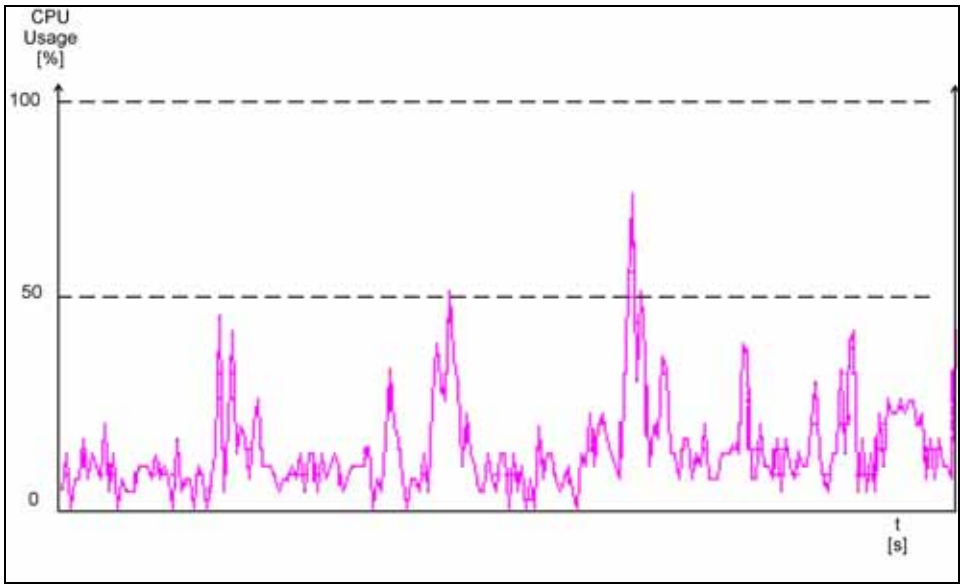

Figure 8. CPU Usage – Users Logged-in, Multiple Applications in use

C. CONCLUSIONS

The results of the software testing showed that the applications specific to the Polish Armed Forces environment are incompatible with thin client technology. On the other hand, office and other popular software applications are not only compatible but their performance is equally efficient as in standalone PCs. The authors believe that the performance of the applications is sufficient enough for the needs of the Polish Armed Forces. The authors also believe that the incompatibility of applications used in tests is not caused by the deficiencies of the thin client technology, but rather by the applications itself. Those applications were produced at a time when nobody really thought about implementing thin client technology, and the market for thin client compatible applications did not exist in Poland. Furthermore, the majority of the Polish market does not require such software. The authors are convinced that in time the IT cost cutting tendency as well as the rising costs of legacy system and applications will force this situation to change.

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IV. COST COMPARISON

A. TECHNOLOGY TRANSFER RESTRICTIONS

In order to investigate technology transfer restrictions, the authors contacted two of the U.S. thin client technology leaders: Sun Microsystems, Inc. and Wyse Technology, Inc. Additionally, the thin client offer of Hewlett Packard (HP) was examined.

The authors contacted a Sun Store representative on February 10, 2006, and were assured that there are no trade restrictions for Sun products. Also, on February 28, 2006, Sun Microsystems Poland was contacted, where once again it was confirmed that the products and technology offered by Sun Microsystems in United States are also available on the Polish market. The Sun products offered in Poland can be found at: <http://pl.sun.com/products/ >.

The authors sent an e-mail to Wyse Technology, Inc. asking for advice on the technology transfer issue. On February 21, 2006, the e-mail from a Wyse Inside Sales Manager was received and directed the authors to the European branch in the UK. From there, the authors were redirected to the German office, where on February 28, 2006, they were informed that, likewise, there are no technology transfer restrictions for Wyse products. They were also told that all Wyse thin clients are produced in Mexico. The authors also learned that Wyse does not have its own representative or branch in Poland. The closest Wyse representative is in Germany. The official distributor for Wyse in Poland is Techmex. Several e-mails were sent in an attempt to try and gather some information about Wyse products offered by Techmex, but have no response has been received from them. Given that Wyse Technology, Inc. has no branch or representative in Poland, plus the lack of response from the Wyse products distributor in Poland, the authors decided not to consider Wyse products for the Polish Armed Forces. In the opinion of the authors, customer support is among the most important factors that influence the decision to choose IT equipment.

The HP sales representative in Poland was also contacted. In this case, the authors were also assured that there are no technology transfer restrictions. There may be

differences in the variety and configurations of HP products offered in the United States and in Poland, but they are caused by different market requirements and company policy, not by any restrictions on technology transfer.

B. SOFTWARE AND LICENSING BASICS

In the Polish market, as well as among government and public institutions, Microsoft software is the most popular. On March 26, 2006, the Polish Ministry of Interior and Microsoft Corporation signed an agreement to which Microsoft offered the Select License Program[54] for all Polish local and central institutions.[55] Unfortunately, the Polish Defense Ministry does not have this type of agreement with Microsoft.

In order to find what types of licenses are needed to consider in models, Microsoft Poland was contacted. The authors were informed about the basics of Microsoft licensing rules and that Microsoft Poland does not sell software, but distributes it to partner companies, which in turn distribute software on the market. Microsoft Poland confirmed that the Polish Armed Forces are eligible for the Microsoft Open License solution in which the software unit cost is approximately 18 percent cheaper than retail.[56] Moreover, as a government institution, the Polish Armed Forces can use a variety of Microsoft Open License designed for government and public institutions called Microsoft Open Government License. This type of license is even lower in price for the Polish Armed Forces[57].

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54 "Detailed info about Microsoft Select Program," (cited 29 March 2006); available from World Wide Web @http://www.microsoft.com/licensing/programs/sel/default.mspx. The prices for the software in this Program are available from World Wide Web @http://download.microsoft.com/download/3/7/b/37b5a043-949a-4f07-956f-233141a1025e/Microsoft%20Cennik%20Select%20Marzec.xls

55 "MSWiA przedluza umowe ramowa Microsoft Select," (cited 29 March 2006); available from World Wide Web @http://www.microsoft.com/poland/centrumprasowe/prasa/06_03/08.mspx

56 Microsoft Poland, Open License, (cited 10 March 2006); available from World Wide Web @http://download.microsoft.com/download/b/8/4/b84c409d-bf0d-426b-ad96-7d2c73e6ce05/Open_i_produkty.pdf

57 Microsoft Poland, Open Government License, (cited 20 March 2006); available from World Wide Web @http://www.microsoft.com/poland/licencje/open/opengov.mspx

The basic rule for licensing software is that every device – thin client, standard PC, or PC used as a terminal - has to have a licensed operating system (OS). In case of thin clients, an OS is usually embedded. Every other software license, such as Microsoft Office or Microsoft Project, depends on network devices. Windows Server 2003 R2 is assumed as the primary server software for the purposes of this project.

The Terminal Services utility in Windows Server 2003 R2 lets the user remotely run applications on a Windows-based server from different types of devices over various network connections. "A server running Terminal Services can be referred to as a Terminal Server (TS)."[58]

The Terminal Server Licensing Requirements of Microsoft Corporation are as follows:

- **Windows Server License** – The Windows Server 2003 R2 licensing model requires a server license for each copy of the server software installed. Terminal Services functionality is included in the Windows Server license.
- **Windows Server Client Access License –** In addition to a server license, a Windows Server Client Access License (CAL) is required. If the user conducts a Windows session, an incremental Terminal Server Client Access License (TS CAL) is required as well. A Windows session is defined as a session during which the server software hosts a graphical user interface on a device. For Windows sessions, a TS CAL is required for each user or device.[59]

> Windows CALs are not required when access to the server software is unauthenticated and conducted through the Internet. Authenticated access is defined as an exchange of user or application credentials between the

58 "Licensing Terminal Server in Windows Server 2003 R2," (cited 20 March 2006); available from World Wide Web @http://www.microsoft.com/windowsserver2003/howtobuy/licensing/ts2003.mspx

59 Ibid.

> server software and a user or device. An example of this exception would be if unidentified users browsed your public Web site. Windows CALs would not be required for those users[60].

Two types of Windows Client Access Licenses are available: device-based or user-based – Windows Device CALs or Windows User CALs. This simply means that a consumer can acquire either a Windows CAL for every device and access network servers or a Windows CAL for every named user and access the consumer's servers.[61]

When the license type is selected (Windows Device CAL or Windows User CAL) a consumer can use the server software in two modes: Per User/Per Device mode or Per Server mode. Both modes are available for Windows Device CAL or Windows User CAL.

In Per User/Per Device mode, a separate Windows CAL (of either type) is necessary for each user or device that accesses or runs the server software on any of the customer's network servers. The number of Windows CALs required has to be the same as the number of users or devices accessing the server software.[62] "Per User/Per Device mode tends to be the most economical designation for Windows CALs in distributed computing environments where multiple servers within an organization provide services across most devices or users."[63] If Per User/Per Device mode is chosen, the choice is permanent.

In Per Server mode, "a separate Windows CAL (of either type) is required for each user or device that accesses or uses the server software on any of consumer's servers. (This does not change the per server connection allowance of one CAL per one connection.)"[64] In Per Server mode "the number of Windows CALs required equals the maximum number of users or devices that may simultaneously access or use the server

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60 Microsoft Corp., "Windows Server 2003 R2 Client Access Licensing Overview," (cited 26 March 2006); available from World Wide Web @http://www.microsoft.com/windowsserver2003/howtobuy/licensing/caloverview.mspx

61 Ibid.

62 Ibid.

63 Ibid.

64 Ibid.

software installed on a particular server. The Windows CALs the consumer acquires are designated for use exclusively with a particular server."[65] If Per Server mode is chosen, the consumer has a one-time right to switch to the other licensing mode—Per User/Per Device mode - and consumer Windows CALs (of either type) would then be used in Per User/Per Device mode instead.[66] "Per Server mode tends to be the most economical designation for Windows CALs in computing environments where a small number of servers have limited access requirements."[67]

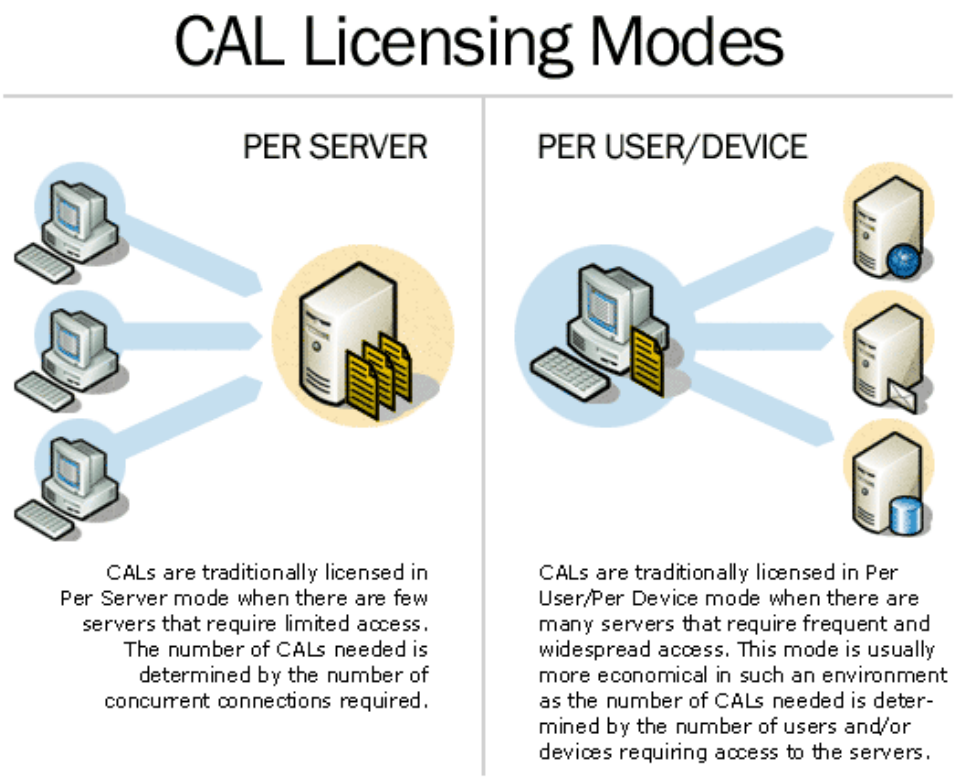

Figure 9. CAL Licensing Modes[68]

65 Microsoft Corp., "Windows Server 2003 R2 Client Access Licensing Overview," (cited 26 March 2006); available from World Wide Web @http://www.microsoft.com/windowsserver2003/howtobuy/licensing/caloverview.mspx

66 Ibid.

67 Ibid.

68 Ibid.

Beside Windows CAL, there are two types of Terminal Server Client Access Licenses: TS Device CAL or TS User CAL. A TS Device CAL permits one device (used by any user) to run Windows sessions on any of the network servers. A TS User CAL permits one user (using any device) to run Windows sessions on any of the network servers. It is possible to use a combination of TS Device CALs and TS User CALs simultaneously with the server software.[69] Terminal Server CALs "are available in Per User/Per Device mode only. In Per User or Per Device mode, a separate TS CAL is required for each user or device that accesses or uses the server software on any server. TS CALs are not available in Per Server mode as Windows sessions are not allowed in Per Server mode."[70]

C. COMPARISON MODELS

In order to compare direct costs of different technology networks, three simple models were created. Whenever in these models server and thin client and PC, or PC used as terminal is mentioned, the complete set (terminal or PC tower, plus 17 inch LCD monitor, standard keyboard, and mouse) will be considered. The other assumption made in these models is that they are built from scratch, i.e. servers, terminals or PC are to be bought and the costs of those elements represent retail prices and the time of research except for Model 3, where legacy PCs are used. The other network infrastructure elements (such as network wiring, hubs and routers) are neglected. The Polish market is the source of prices, which are reported in U.S. dollars before taxes and are calculated through use of the exchange course $1= 3.268zl. Microsoft software prices are provided in euros and converted to dollars using the exchange rate €1= $1.203. Costs are calculated using the cheapest products offered on the market by a specific company. The authors did not try to compare products of different companies. The various offers were used only to illustrate relative cost.

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69 "Licensing Terminal Server in Windows Server 2003 R2," (cited 20 March 2006); available from World Wide Web @http://www.microsoft.com/windowsserver2003/howtobuy/licensing/ts2003.mspx

70 Ibid.

The authors decided to use per device Windows CALs and Windows Terminal Server CALs in Per User/Device Mode for software. In addition to the required software, Microsoft Office Pro 2003 package and Microsoft Project Pro 2003 were added. Moreover, the authors decided to include Microsoft Exchange Server – noting that electronic mail is a universal feature. Additionally, a decision was made to include in software package the software assurance option (L+SA). Software assurance is an addition to the license being valid for two years with the following rights:

- Install Microsoft Office components on the home PC or other devices;
- New software versions without additional costs during the time SA is valid;
- Internet TechNet On-line Concierge – the internet Microsoft real-time support;
- Creating a spare server with the software already acquired – this is for use in case of a primary server crash;
- Participation in eLearning program – internet-based courses on Microsoft products.[71]

The prices for the models' software were provided by Bonair S.A., Microsoft Gold Certified Partner. They do not represent Open Government License, but Open license prices valid on March 22, 2006.

71 Microsoft Poland, Open License, (cited 10 March 2006); available from World Wide Web @http://download.microsoft.com/download/b/8/4/b84c409d-bf0d-426b-ad96-7d2c73e6ce05/Open_i_produkty.pdf

1. Model 1

This model is composed of:

Model 1
➢ 1x server
➢ 30x thin client terminals
➢ 1x Office Pro 2003 Win32 Polish Lic/SA Pack OLP NL
➢ 1x Project Pro 2003 Win32 Polish Lic/SA Pack OLP NL w/1 ProjectSvr CAL
➢ 1x Exchange Svr 2003 English OLP NL
➢ 30x Exchange CAL 2003 All Languages OLP NL Device CAL
➢ 30x Windows Server CAL 2003 Polish OLP NL Device CAL
➢ 30x Windows Terminal Svr CAL 2003 WinNT Polish OLP NL Device CAL

2. Model 2

This model is composed of:

Model 2
➢ 1x server
➢ 30x PCs
➢ 30x Office Pro Win32 Polish Lic/SA Pack OLP NL
➢ 30x Project Pro Win32 Polish Lic/SA Pack OLP NL w/1 ProjectSvr CAL
➢ 30x Windows XP Professional Polish Upg/SA Pack OLP NL
➢ 1x Exchange Svr 2003 English OLP NL
➢ 30x Exchange CAL 2003 All Languages OLP NL Device CAL
➢ 30x Windows Server CAL 2003 Polish OLP NL Device CAL

3. Model 3

This model is composed of:

Model 3
➢ 1x server
➢ 30x PCs used as terminals
➢ 1x Project Pro Win32 Polish Lic/SA Pack OLP NL w/1 ProjectSvr CAL
➢ 30x Windows XP Professional Polish Upg/SA Pack OLP NL
➢ 1x Exchange Svr 2003 English OLP NL
➢ 30x Exchange CAL 2003 All Languages OLP NL Device CAL
➢ 30x Windows Server CAL 2003 Polish OLP NL Device CAL
➢ 30x Windows Terminal Svr CAL 2003 WinNT Polish OLP NL Device CAL

D. COST COMPARISON

As outlined in the previous chapter, switching from conventional desktop PCs to server-based computing can significantly reduce the TCO.

The Gartner Group introduced the TCO term and analysis in the late 1990s. Since then, the Gartner Group model has been used and modified by a number of IT research, audit and consulting firms. According to Gartner Group analysts, there are many costs associated with IT infrastructure which can be divided into the following two categories: hard (or direct) and soft (or indirect) costs. Everybody agrees that the central idea behind estimating TCO is the focus on both direct and indirect cost as a measure of estimating the total costs of maintaining the IT infrastructure.

To help organizations identify all the variables associated with the IT infrastructure costs, Gartner Group created a model called "TCO Model v4 – Distributed Computing Chart of Accounts." This model can be seen in Figure 10.

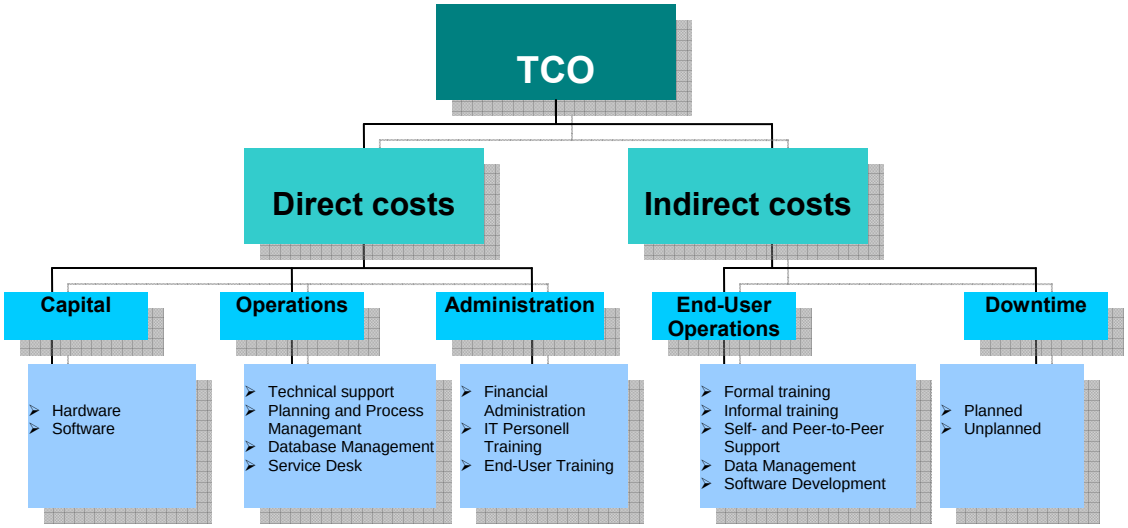

Figure 10. TCO Model v4 by Gartner Group (source: Gartner Group)

The direct and indirect costs are divided into five categories. Capital, administration and operations costs are direct costs; end-user operations and downtime are indirect costs.[72]

According to the Gartner Group's v4 model,

> Direct costs arise from the usage of hardware and software, from human resources responsible for operating the IT infrastructure and from administration of the IT department. In this case hardware and software costs are measured through traditional accounting figures like deprecation and leasing costs. This category does not include wages to be paid for employees making the investment decisions or carrying out administrative tasks. This is covered by the category Administration that includes costs for tasks like budgeting and controlling, end-user and IT staff training. Operations include all remunerations paid for internal and external staff responsible for running the IT infrastructure.[73]

[72] M. Stock, "Technologies for thin client architectures," Zurich 2001.

[73] Ibid.

Usually, decision makers do not consider indirect costs in making their decisions. However, during the last decade the indirect costs have tripled[74]. According to Figure 11 almost half of the IT expenses are soft.

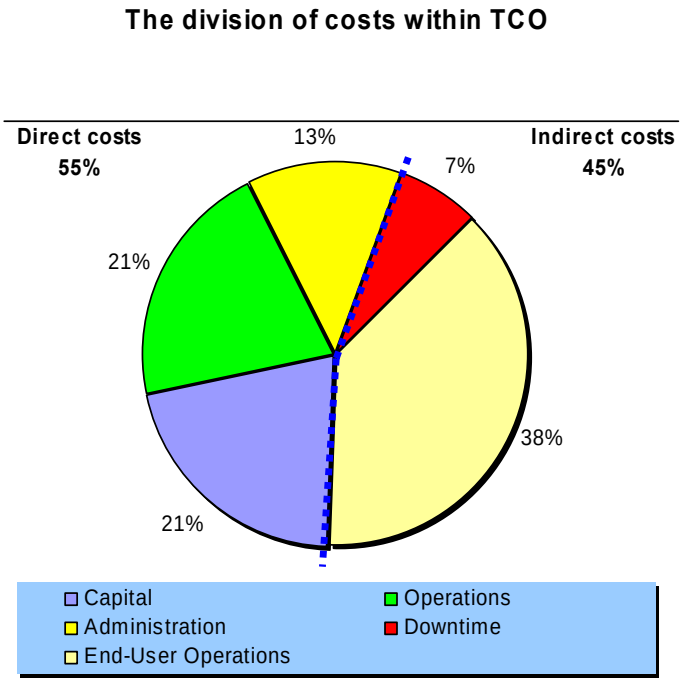

Figure 11. The division of costs within TCO (source: Gartner Group)

Indirect costs arise from reduced productivity, additional time spent on formal and informal training, and downtime. "Lost productivity is caused by end-users carrying out tasks that should be carried out by the responsible IT staff or that should not be carried out at all. This includes self- and peer to peer support, data management, end-user software development, the use of IT infrastructure for private tasks."[75]

To determine TCO accurately, thin client and PCs usage tracking is necessary. The best way to do so is probably use the research of companies like Gartner Group, Zona Research or Microsoft. In 1996, Zona Research calculated 57 percent savings in TCO in five years for Wyse Windows terminals versus PCs. In 1997, Microsoft claimed

74 M. Stock, "Technologies for thin client architectures," Zurich 2001.

75 Ibid.

that in the same scenario 46 percent savings would be possible. In the same year, the Gartner Group claimed 22 percent savings in TCO for NCs versus PCs.[76] The IDC research "Thin Computing ROI: The Untold Story," conducted in 2005 and sponsored by Wyse Technology, provided very valuable results about cost comparison between PCs and thin clients. IDC interviewed 11 Wyse customers who changed their PC-based networks to thin client networks and

> the customers in this study included hospitals, government agencies, retail stores, financial institutions, and a services company. Their users include professionals such as doctors, nurses, and financial analysts who need reliable information systems. The companies interviewed ranged in size from 3,100 to 30,000 employees. Only one company had 100 thin client users. On average the companies had migrated about 18 percent of their PC users to thin clients. They were widely distributed organizations (2,500 sites on average) that chose to widely distribute the thin client users to over a third of all the sites.[77]

These are some of IDC's findings. The average annual cost of using a PC or thin client per user is significantly lower in the thin clients' case. Figure 12 presents the annual costs of workers using thin clients and PCs found by IDC.

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[76] M. Sheehan, "Considering Thin Client Computing for Higher Education" in Cause/Effect journal, Volume 21 number 3 1998.

[77] B. O'Donnell, "Thin Client Computing ROI: The Untold Story," (cited 04 April 2006); available from World Wide Web @http://au.wyse.com/resources/whitepapers/PDF/IDC_ROI.pdf

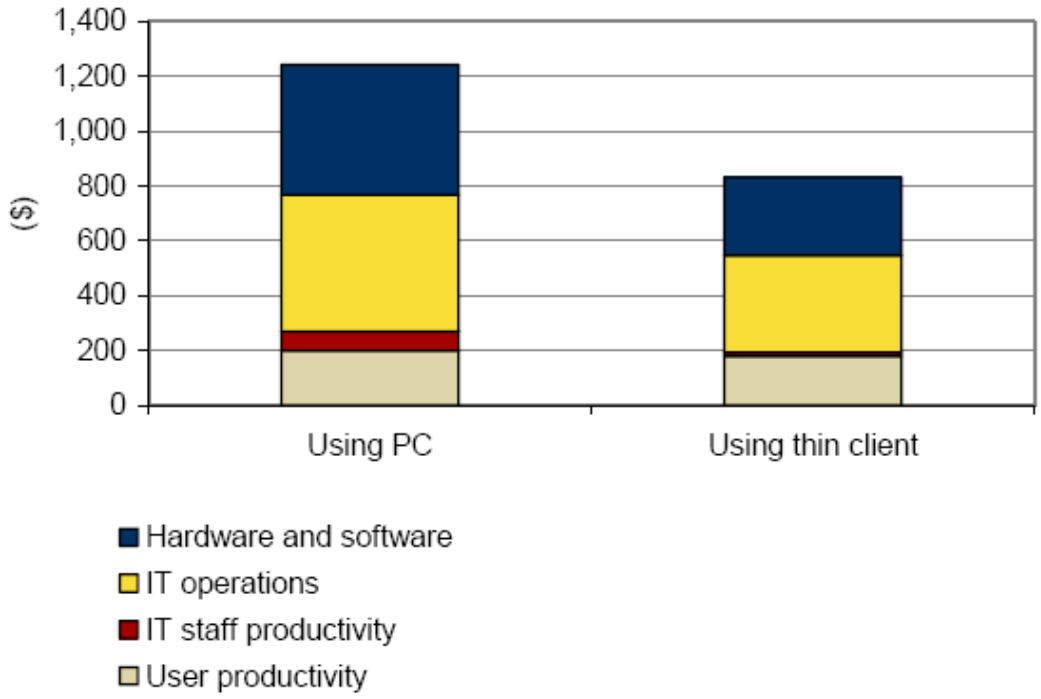

Figure 12. Average Annual Cost per User (source: IDC, 2005)

The interviewed customers of Wyse were able to identify the following benefits of using thin clients instead of PCs in the following areas:

- "**Reduced hardware and software costs by 40 percent**. Thin clients deployed in this study cost 27 percent less to purchase, install, and maintain than the PCs that they replaced and support 50 percent more users (4.9 users per thin client).
- **Reduced IT operations costs by 29 percent.** Thin clients enable consolidation of hard drives in fewer locations, reducing the operations expenses associated with physical desktop support (site visits) as well as the help desk.
- **Increased IT staff productivity by 78 percent.** Heavily distributed environments incur an overhead tax associated with user support. The consolidated nature of thin clients leveraged by the deployment using Wyse Device Manager software not only enabled customers to reduce

staff but also enabled the remaining IT staff members to spend 78 percent less time on low-value infrastructure support functions and more time on proactive or business-related activities.

- **Reduced worker downtime by 88 percent.** Downtime is defined as time that knowledge workers do not have access to the applications they need to do their jobs. Thin clients in a well-managed environment (e.g., Wyse Device Manager) suffer 51 percent fewer downtime events and require 72 percent fewer help desk calls, resulting in an increase in user productivity."[78]

Figure 13 presents benefits of switching to thin clients identified by interviewed companies.

	Year 1	Total	Average
Equipment savings	$13 646	$46 023	$15 341
Operations efficiency	$1 845	$17 322	$5 774
IT staff productivity	$2 669	$9 969	$3 323
User productivity	$8 084	$47 802	$15 934
Total benefits	**$26 244**	**$121 116**	**$40 372**

Figure 13. Benefits Analysis – per 100 Thin Client Users (source: IDC, 2005)

The cumulative costs of using PCs and thin clients over a three-year period are presented in Figure 14.

78 B. O'Donnell, "Thin Client Computing ROI: The Untold Story," (cited 04 April 2006); available from World Wide Web @http://au.wyse.com/resources/whitepapers/PDF/IDC_ROI.pdf

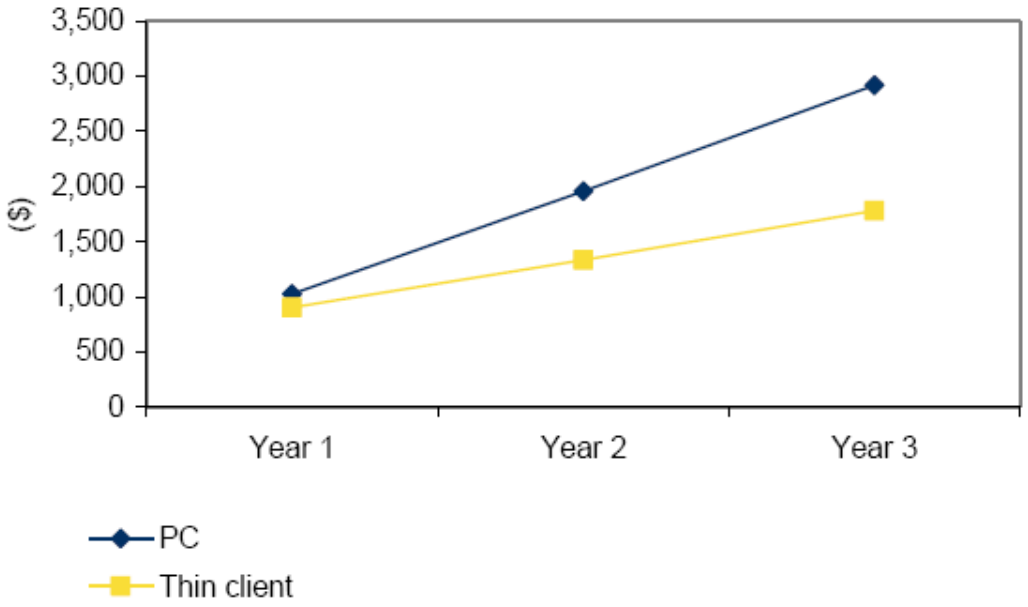

Figure 14. Cumulative Cost of PC Environment versus Thin Client Environment – Per System (source: IDC, 2005)

Another very important aspect of the cost of using IT equipment is power usage. Thin Client Computing in Scottsdale, AZ conducted a study in 2001 that compared power usage of PCs and thin clients in office environments.[79] This was a practical study where an actual operating business office was used to ensure that all results would reflect real-world usages.

> Given the nature of the test environment, the methodology used, and, the data collected we were able to accurately model the total power usage costs for both PC and thin client networks of various sizes from 5 to 100 users. The annual kilowatt hour usage of each device was calculated. Each network size was analyzed for the correct number of PC's or thin clients, monitors, file servers, hubs/switches, modems and terminal servers. The cost of powering each type of network is the sum of the annual kilowatt hours for all devices in that network, times the average cost per kilowatt hour. Since computers and related devices generate heat from the power consumed, there is an additional factor to consider- the cost of cooling. Although the amount of power required for cooling is site specific, it usually takes approximately 1 unit of electricity to move 2 units of heat.

79 C. Anderson, S. Greenberg, J. Mitchell-Jackson, "Power to the People: Comparing Power Usage for PCs and Thin Clients in an Office Network environment" in Thin Client Computing, (2001 [cited 05 April 2006]); available from World Wide Web @http://www.profiletechnh.com/TC%20White%20Papers/Power_Study.pdf

This premium was also included in our calculations. The savings gained by replacing PC's with Thin Clients is found by subtracting the difference between the total network costs respectively. The network cost curve was calculated at ~$.10 per kWh which is at the low end of current energy rates. Savings are shown for both ~$.10 and ~$.20 per kWh.[80]
Figure 15 presents annual electricity savings for 5 to 100 users.

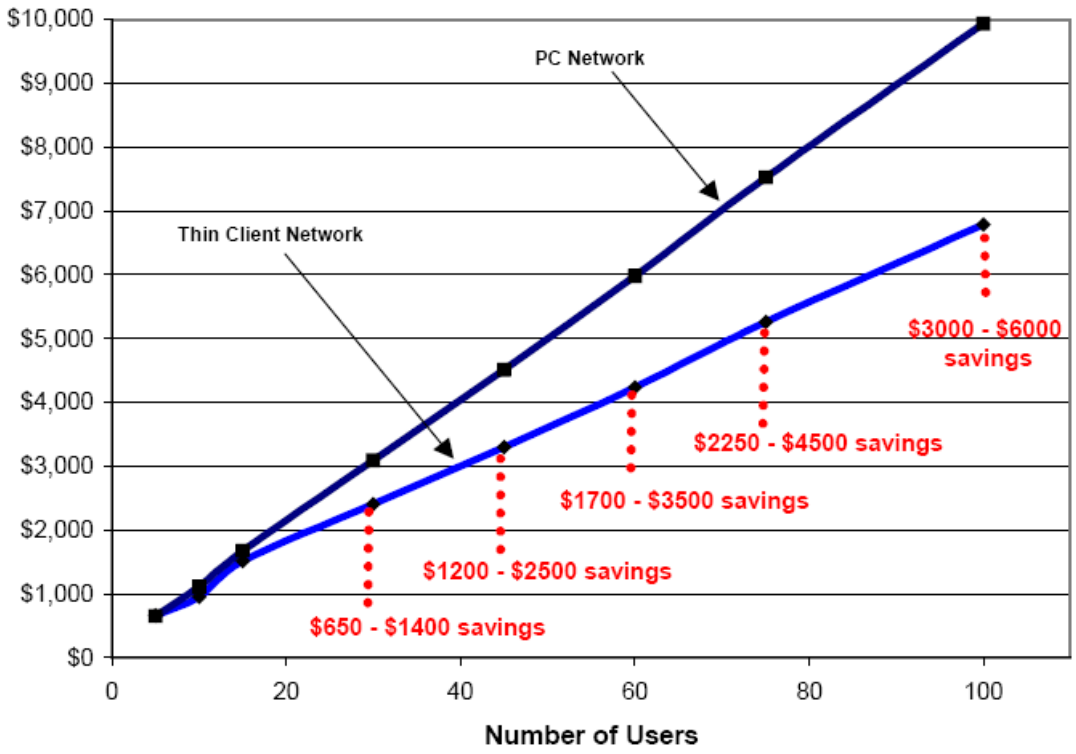

Figure 15. Annual Electricity Cost and Savings for 5 to 100 Users (source: Thin Client Computing)

Thin Client Computing showed in its study that thin clients are nearly 7 times more power-efficient than PCs – 10 watts versus 69 watts. Furthermore, thin clients generate less heat, and when this factor is added, power usage for PCs equals 103.5 watts versus 15 watts for thin clients. The other study results showed that the thin client networks cost less to power than PC networks.

80 C. Anderson, S. Greenberg, J. Mitchell-Jackson, "Power to the People: Comparing Power Usage for PCs and Thin Clients in an Office Network environment" in Thin Client Computing, (2001 [cited 05 April 2006]); available from World Wide Web @http://www.profiletechnh.com/TC%20White%20Papers/Power_Study.pdf

> To develop an accurate picture of the true cost savings that results from using thin clients, it was important to take into account all of the devices that comprise a network. This included the servers that host the applications which the thin client displays, and, the devices which are common to both types of networks. These factors were expected to diminish the overall savings resulting from the use of thin clients. Yet, even with these factors taken into account, we found that thin client networks cost from 30 – 60 percent less to power. For example, a small business with 100 users can save as much as $6,000 per year.[81]

The study also showed that overall power savings increases as the size of the network increases.

> The most obvious factor here is the increased number of low power devices found in larger networks. For each PC that is replaced by a thin client there will be an additional power savings. However, the number of terminal servers required to support thin clients does not increase in a linear pattern: twice as many clients does not mean twice as many terminal servers. As clusters of servers are built to support thin client sessions, greater economies of scale are quickly realized. Departmental servers, and servers in remote offices, becoming increasingly unnecessary. There is no need for remote servers to store files, forward email, or host databases, when all the applications and data are stored centrally. Our findings suggest savings of $59,760 for a 1000 users and $149,391 for 2500 users. However, we suspect that actual measurements of large scale networks could show even greater savings.[82]

In this project, the authors concentrated only on the direct cost part of TCO – capital. The gathering of all necessary data for a complex cost comparison was impossible partially because the authors had no access to necessary data, and partially because such an endeavor would have needed a long time for research purposes.

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81 C. Anderson, S. Greenberg, J. Mitchell-Jackson, "Power to the People: Comparing Power Usage for PCs and Thin Clients in an Office Network environment" in Thin Client Computing, (2001 [cited 05 April 2006]); available from World Wide Web @http://www.profiletechnh.com/TC%20White%20Papers/Power_Study.pdf

82 Ibid.

1. Model 1

For the needs of the project and creation of Model 1, the four most representative thin clients and servers found on the Polish market were chosen. The tables below compare the direct costs associated with the purchase of the required number of stations and selected software.

Type of software	Quantity	Net price	Net price
Office Pro 2003 Win32 Polish OLP NL	1	€ 655,00	$787,97
Project Pro 2003 Win32 Polish OLP NL w/1 ProjectSvr CAL	1	€ 1 154,00	$1 388,26
Exchange Svr 2003 English OLP NL	1	€ 731,00	$879,39
Exchange CAL 2003 All Languages OLP NL Device CAL	30	€ 70,00	$84,21
Windows Server CAL 2003 Polish OLP NL Device CAL	30	€ 26,00	$31,28
Windows Terminal Svr CAL 2003 WinNT Polish OLP NL Device CAL	30	€ 72,00	$86,62
	Total price	**€ 2 708,00**	**$3 257,72**

Table 3. Software Procurement Cost – Model 1

The following table presents costs of hardware from two thin client manufacturers present on the Polish market that the authors found most cooperative – Sun Microsystems and Hewlett Packard.

Sun Microsystems solution[83]		
Product name	**Catalog Unit Price**	**Packet Price (30 units)**
Sun Ray 1g Ultra-Thin Client	$349,80	$10 494,00
17-inch Flat Panel HP L1706	$298,00	$8 940,00
Sun Fire X2100 Server	$2 110,10	$2 110,10
Total price		**$21 644,10**
Total procurement cost with software		**$24 901,82**
Sun Ray 170 Ultra-Thin Client, all-in-one 17-inch Flat Panel	$1 013,13	$30 393,90
Sun Fire X2100 Server	$2 110,10	$2 110,10
Total price		**$32 504,00**
Total procurement cost with software		**$35 761,72**
Hewlett Packard solution[84]		
Product name	**Catalog Unit Price**	**Packet Price (30 units)**
Terminal HP Compaq t5125 Thin Client	$347,30	$10 419,00
17-inch Flat Panel HP L1706	$298,00	$8 940,00
Server HP ProLiant DL140 G2 (405639-421)	$1 869,30	$1 869,30
Total price		**$21 228,30**
Total procurement cost with software		**$24 486,02**
Terminal HP Compaq t5520 Thin Client	$483,50	$14 505,00
17-inch Flat Panel HP L1706	$298,00	$8 940,00
Server HP ProLiant DL140 G2 (405639-421)	$1 869,30	$1 869,30
Total price		**$25 314,30**
Total procurement cost with software		**$28 572,02**

Table 4. Hardware Procurement Cost – Model 1

[83] Data provided by Sun Microsystems Poland representative.

[84] Data provided by Hewlett Packard Poland representative.

2. Model 2

In this model, the hardware and basic software costs of the network built with 30 PCs and server were computed. To find the hardware costs, two Polish computer distributors were contacted, and the data they provided is presented below.

Type of software	Quantity	Net price	Net price
Office Pro 2003 Win32 Polish OLP NL	30	€ 655,00	$787,97
Project Pro 2003 Win32 Polish OLP NL w/1 ProjectSvr CAL	30	€ 1 154,00	$1 388,26
Exchange Svr 2003 English OLP NL	30	€ 268,00	$322,40
Exchange CAL 2003 All Languages OLP NL Device CAL	1	€ 731,00	$879,39
Windows Server CAL 2003 Polish OLP NL Device CAL	30	€ 70,00	$84,21
Windows Server CAL 2003 Polish OLP NL Device CAL	30	€ 26,00	$31,28
	Total price	**€ 2 904,00**	**$3 493,51**

Table 5. Software Procurement Cost – Model 2

Optimus[85]		
Product name	**Catalog Unit Price**	**Packet Price (30 units)**
Optimus Smart D200ET	$421,50	$12 645,00
OptiView L17v Flat Panel LCD	$276,00	$8 271,00
Optimus NServer ME 240 G5 - ver. SCSI	$3 399,00	$3 399,00
Total price		**$24 315,00**
Total procurement cost with software		**$27 808,51**
Vobis[86]		
Product name	**Catalog Unit Price**	**Packet Price (30 units)**
Vobis Digital MX346800C	$520,00	$15 600,00
Vobis 710N 17-inch Flat Panel	$305,00	$9 170,00
Optimus NServer ME 240 G5 - ver. SCSI	$3 399,00	$3 399,00
Total price		**$28 169,00**
Total procurement cost with software		**$31 662,51**
Hewlett Packard[87]		
HP Compaq DX2000	$503,30	$15 099,00
17-inch Flat Panel HP L1706	$298,00	$8 940,00
Server HP ProLiant DL140 G2 (405639-421)	$1 869,30	$1 869,30
Total price		**$25 908,30**
Total procurement cost with software		**$29 401,81**

Table 6. Hardware Procurement Cost – Model 2

3. Model 3

In Model 3, only software licenses costs are provided, because all PCs used in the network would be legacy equipment.

85 Data provided by Optimus Poland representative.

86 Data provided by Vobis Poland representative.

87 Data provided by Hewlett Packard Poland representative.

Type of software	Quantity	Net price	Net price
Office Pro 2003 Win32 Polish OLP NL	1	€ 655,00	$787,97
Project Pro 2003 Win32 Polish OLP NL w/1 ProjectSvr CAL	1	€ 1 154,00	$1 388,26
Exchange Svr 2003 English OLP NL	30	€ 268,00	$322,40
Exchange CAL 2003 All Languages OLP NL Device CAL	1	€ 731,00	$879,39
Windows Server CAL 2003 Polish OLP NL Device CAL	30	€ 70,00	$84,21
Windows Terminal Svr CAL 2003 WinNT Polish OLP NL Device CAL	30	€ 26,00	$31,28
Windows Terminal Svr CAL 2003 WinNT Polish OLP NL Device CAL	30	€ 72,00	$86,62
	Total price	**€ 2 976,00**	**$3 580,13**

Table 7. Software Procurement – Model 3

To work as a terminal a legacy PC must run Windows XP. Therefore, any PC that meets the following requirements can be used as a terminal:

- PC with 300 megahertz (MHz) or higher processor clock speed recommended; 233 MHz minimum required (single or dual processor system); Intel Pentium/Celeron family or AMD K6/Athlon/Duron family, or compatible processor recommended.
- 128 megabytes (MB) of RAM or higher recommended (64 MB minimum supported; may limit performance and some features).

E. CONCLUSIONS

Thin clients and thin client computing can be an efficient way to optimize investments in IT and create relatively cheap and definitely secure networks. Compared with desktop PCs, thin clients present lower acquisition and support costs as well as

higher worker and IT staff productivity.[88] Furthermore, the research data show that a thin client solution generates significant savings in overall cost of ownership.

Additionally, if it is taken into consideration the fact that respected companies recommend a three to six-year purchasing cycle for personal computing hardware, the thin client alternative and the vision of a centralized upgrading process leaves no illusions as far as the final solution is concerned.

However, in the comparison of costs, the network of legacy PCs is the most cost-efficient one. By adopting the model of PCs serving as Windows Terminals, the lifecycle of old personal computers can be extended, and at the same time the ability to run the latest applications to include modern desktop environments can be retained.

As mentioned, this solution can definitely extend the useful life of legacy hardware and can lower upfront costs of a new network. Yet at the same time this option requires significantly more maintenance and power than the solely thin client-based networks. Moreover, the monetary benefits are not the only ones that make thin clients an attractive alternative to desktop PC networks. In a defense environment, the security factor is almost as important as costs and in many cases even more important.

Therefore, it is obvious that when taking into account all factors of the network thin clients are the preferred solution.

Table 8 contains the procurement cost comparison of selected (cheapest) solutions.

[88] B. O'Donnell, "Thin Client Computing ROI: The Untold Story," (cited 04 April 2006); available from World Wide Web @http://au.wyse.com/resources/whitepapers/PDF/IDC_ROI.pdf

Package	Workstations	Flat Panel LCD's	Server	Licenses	Total Cost
30 Thin Clients	$10 419,00 (30*$347,30)	$8 940,00 (30*$298,00)	$1 869,30	$3 257,72	**$24 486,02**
30 PC's	$15 099,00 (30*$503,30)	$8 940,00 (30*$298,00)	$1 869,30	$3 493,51	**$29 401,81**
30 Legacy PC's working as Windows Terminals	Prior Investment	$8 940,00 (30*$298,00)	$3 399,00	$3 580,13	**$15 919,13**

Table 8. Models' Costs Comparison

V. RECOMMENDATIONS

Thin clients can be an effective alternative for standalone PC networks. Thin clients not only are more attractive because of purchase costs, but more importantly they provide greater security and control over the network. This, in a defense environment, is the most critical factor. As shown in the project, thin clients are more energy efficient than standalone PCs. This fact in context with the policy of reducing overhead costs gives thin client another important advantage. The cost of network maintenance is also significantly smaller in the case of thin clients. Moreover, the lifespan of these devices – in sense of up-to-datedness and the ability to run new software - is literary restricted only by the physical life span of the thin client itself. This provides great savings in the long run.

The authors researched the possible technology transfer restrictions and found none. Due to this research and the cooperation of thin client and software producers, plus the lack of cooperation from others, the authors found out that thin client technology is easily available in Poland, and all major producers of this technology offer their products on the Polish market. Furthermore, the authors examined the service and support offered by thin client producers on the Polish market. As a result of this research and examination, the authors believe that the best possible provider of the thin clients (from the contacted ones) are Sun Microsystems and Hewlett Packard, while Wyse Technology would not be recommended because of the lack of reliable representation and service and support services.

This project has shown that thin clients are able to run and execute the most commonly used applications in ways that are no worse than standalone PCs. The tests conducted by the authors resulted in the opinion that thin clients are reliable and effective. They are also user friendly and no more complicated in use than standalone PCs. Unfortunately, applications and software specific to the Polish Armed Forces proved to be incompatible with thin client technology. This is mainly due to the fact that those applications can be considered legacy software, which was not designed for thin

client computing for a simple reason – thin client computing was not popular at the time the software was created and remains unpopular and widely unavailable even today. Incompatibility of the representative bulk of applications and software used in the Polish Armed Forces is a significant hindrance in implementing thin client technology. The development of the software that is compatible with thin client computing cannot be feasibly done at once, and the costs associated with such a development are significant. However, in the course of time the standalone PC networks used in the Polish Armed Forces will become more and more costly in maintenance, administration and security. Therefore, it is not impossible that in the near future the cost of adopting applications and software to the thin client computing environment will become an attractive alternative to maintaining standalone PC networks and running legacy applications.

The authors recommend the following thin client implementation policy for the Polish Armed Forces:

1. Introduce the thin clients in an environment where the legacy and non-compatible applications are not used. The majority of the users in the Polish Armed Forces use only the office applications and internet browsers. Therefore, thin clients can be successfully implemented instead of standalone PCs, for example:
   - For internet access terminals in units, bases and especially on abroad deployment such as peacekeeping missions, as to provide the opportunity to browse the internet and keep in touch with families back home.
   - In computer classrooms and laboratories.
   - In units for the purpose of office applications, such as document editing and storage, creating presentations or keeping databases.
2. For the time being, use the legacy programs and standalone PCs in other environments where it is necessary and incorporate these PCs into the thin client network. These standalone PCs would have dual tasks:

- Run legacy software that is not compatible with the thin client environment.
- Serve as terminals to access and run other compatible and new applications. This will generate significant savings because when new software applications need to be implemented, the standalone PCs will not have to be replaced for new ones too (they will execute this applications from servers), and the legacy software could be used at the same time.

3. Test and evaluate performance of implemented thin client technology in order to use the results in eventual new software development.
4. Use the savings generated by implementation of thin clients to develop applications that are compatible with the thin client computing environment.

The modern armed forces rely greatly on IT not only as a communication and command tool, but also as office education tools. The widespread IT evolution will not stop and in near future it can be expected that every institution, both government and non government, will increase its need of IT in day-to-day operations. Therefore, it is obvious that a cheaper, more cost-efficient, and at the same time, not inferior to standalone PCs, solution is needed. The authors strongly recommend implementation of the thin client technology as the solution to this need. This can generate a significant amount of savings, which can help with greater levels of computerization of the Polish Armed Forces, improve the security of the networks, and provide the access to IT to a greater number of users.

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APPENDIX TECHNICAL SPECIFICATIONS OF THE SELECTED EQUIPMENT

Sun Microsystems[89]

Sun Ray 1g Ultra-Thin Client	Hardware Requirements • At least 95MB of disk space. • At least 40 MB of RAM for each active user. • At least one ethernet interface installed on the Sun Ray server. • A monitor, keyboard, and mouse for each Sun Ray 1g • Smart Cards (optional)
Sun Ray 170 Ultra-Thin Client, all-in-one 17-inch Flat Panel	Hardware Requirements • A server based on the UltraSPARC or x86 architecture. • At least 95MB of disk space. • At least 40 MB of RAM for each active user. • At least one ethernet interface installed on the Sun Ray server. • Mouse for each Sun Ray 170. • Smart Cards (optional).
Sun Fire X2100 Server	**Processor:** AMD Opteron Model 175 Processor **Memory**: 4-GB Memory **Hard Drive**: 250-GB 7200 RPM SATA Disk Drive **Ports:** 2 x 10/100/1000 Ethernet Ports 6 USB 2.0 Ports 1 PCI Express x8 Slot

89 All data provided by Sun Microsystems representative.

Hewlett Packard[90]	
Terminal HP Compaq t5125 Thin Client	**Processor:** VIA 400 MHz **Flash Memory:** 32 MB **Memory:** 128 MB DDR SDRAM **Graphics:** Via S3 Graphics **Ports:** 4 USB 2.0, 1 Serial, 1 Parallel, 1 PS/2, 1 RJ-45 (NIC)
Terminal HP Compaq t5520 Thin Client	**Processor:** VIA 800 MHz **Flash Memory:** 64 MB **Memory:** 128 MB DDR SDRAM **Graphics:** Via S3 Graphics **Ports:** 4 USB 2.0, 1 Serial, 1 Parallel, 1 PS/2, 1 RJ-45 (NIC)
Server HP ProLiant DL140 G2 (405639-421)	**Processor:** Intel® Xeon® 3,40 GHz processor **Memory**: 4GB Memory **Hard Drive**: 250-GB 7200 RPM SATA Disk Drive **Ports:** 2 x 10/100/1000 Ethernet Ports 4 USB 2.0 Ports 1 PCI Express x8 Slot 1 PCI-X 133MHz

90 All data provided by Hewlett Packard representative.

Optimus & Vobis[91]	
Optimus Smart D200ET	**Processor:** Intel Celeron D 331 2,66Ghz FSB533MHz **Memory:** 512MB DDR2 533MHz **Graphics:** S3 Savage max.64MB **Hard Drive:** 80GB 7200rpm ATA c.2MB **Ports:** 1x10/100 Ethernet Port 1 Serial, 1 Parallel, 4 USB 2.0 1 RJ-45 (NIC)
Optimus NServer ME 240 G5 - ver. SCSI	**Processor:** Intel® Xeon® 3,80 GHz processor **Memory**: 4GB Memory **Hard Drive**: 2 x 80GB 7200rpm SATA Disk Drives **Ports:** 2 x 10/100/1000 Ethernet Ports 5 USB 2.0 Ports 1 PCI Express x8 Slot 1 PCI-X 64bit/100MHz
Vobis Digital MX346800C	**Processor:** Intel Celeron D 346 3,06Ghz FSB533MHz **Memory:** 512MB DDR2 400MHz **Graphics:** S3 Unichrome Pro 128MB **Hard Drive:** 80GB 7200rpm ATA c.2MB **Ports:** 1x10/100 Ethernet Port 1 Serial, 1 Parallel, 4 USB 2.0 1 RJ-45 (NIC)

91 All data provided by Optimus and Vobis representative.

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